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Solar photovoltaic in Malaysia: The way forward

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A B S T R A C T

This paper examines solar photovoltaic (PV) in Malaysia. First, it analyzes the current energy demand in Malaysia and discusses some of the national policies and the installations of solar PV in urban and rural areas in the country. Next, the general Feed-In Tariff (FiT) scheme is explained, indicating its potential as one of the investment options for Malaysians. Finally, the loan financing option for solar PV is presented, providing examples that have been implemented in other countries, as well as explaining the Green Technology Financing Scheme (GTFS) for companies and the proposed soft loan scheme for individual households in Malaysia. It also analyses the impact of the proposed interest rate to household consumers in Malaysia, in terms of total profit, net present value and internal rate of return. It is found that the FiT scheme could potentially help in increasing renewable energy penetration, particularly for solar PV. To provide upfront capital for solar PV installation, it is shown that the GTFS is a good financial source for companies while for individual home owners, a soft loan facility from banking institutions is a feasible source if the interest rate is 5% or less.

Contents

1. Introduction

Energy is a fundamental aspect to people's life, and is essential not only for individuals but also for various sectors, including agricultural, transportation as well as for industrial activities that

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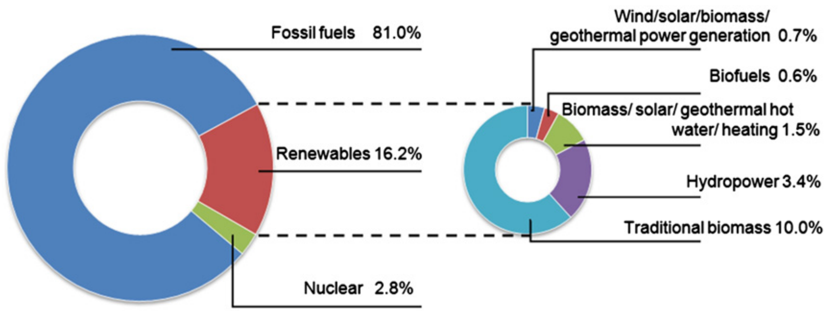

Fig. 1. Renewable energy share of global final energy consumption, 2009. Adapted from [8].

are vital to the social and economic growth of every country. In 2011, the International Energy Outlook projected that the world's energy consumption will rise from 533 Exajoules (EJ)[1] in 2008 to 812 EJ in 2035, a significant growth of 53% [1]. The increase of energy demand occurs in countries outside of the Organization for Economic Cooperation and Development (non-OECD), an increase of 85% from 2008 to 2035, which is more than 5 times the requirement of the OECD countries [1].

This energy demand can be supplied from various resources which can be divided into two categories; non-renewable and renewable. The former is energy that cannot be replenished in the near future, while the latter is derived from natural processes that are constantly replenished [3]. Typical examples of non-renewable energy sources are coal, petroleum and natural gas. As for renewable sources, these include energy generated from solar, wind, wave, biomass, geothermal and hydro [4]. Both non-renewable and renewable energy sources can be used to produce secondary energy sources including electricity and hydrogen [3].

In the last decade, both the government and private sectors all over the world are trying to cut the dependency on fossil fuels, by optimising existing technologies to minimise the energy consumption, as well as venturing into renewable technologies. However, a series of events that occurred recently will further accelerate the penetration of renewable energy resources as an alternative to fossil fuels. For example, in April 2010, the world experienced a significant oil leak as a result of a subsea explosion in the Gulf of Mexico. This leak has had a massive impact on both the environment and the economy of the vicinity [5]. Next, the price of oil surged from $82 per barrel in November 2010 to more than $112 per barrel in April 2011 amid fears of political unrest in the Middle East and Africa. The price is expected to increase in the long term, averaging more than $125 per barrel by 2035 [1]. Also, in March 2011, radioactive leakage from four tsunami-damaged nuclear reactors in Fukushima Daiichi in Japan triggered worldwide panic [6], which consequently has greatly influenced the national energy policies in countries using nuclear energy. As a result of this catastrophic event, a number of safety measures were then implemented by governments worldwide, such as conducting a safety review on all nuclear plants (e.g., the USA, Spain and the UK), shutting down old nuclear plants (Germany) and suspending new nuclear plant approvals (China) [7]. Besides the cost factor, more and more people have realised that the source of energy also needs to have less environmental impact, which can be fulfilled by alternative energy sources.

According to the report by the Renewable Energy Policy Network for the 21st Century (REN21) [8], presently, about 81% of the world's energy consumption is supplied by fossil fuels, 16% from renewable sources and the rest from nuclear, as illustrated in Fig. 1. The report indicates that renewable energy replaces fossil and nuclear fuels in four distinct markets: power generation, heating and cooling, transport fuels, and rural/off-grid energy services.

Malaysia is an example of a country which is heavily dependent on fossil fuels. But recent years, Malaysia has started to adopt renewable energy policies, with the climax being the Renewable Energy Act being legislated in 2011.

This paper reviews the latest progress and developments of solar photovoltaic as one of the identified major contributor to renewable energy growth in Malaysia. Malaysia is a non-OECD country that is experiencing a strong economic growth with a steady increase in energy demand. To ensure the the country's economy is resilient and sustainable in the long run, the Government of Malaysia (GoM) has started to elevate the usage of renewable in delivering its energy need. Section 2 presents an overview of Malaysia's energy demand and its journey towards renewable energy implementation as well as the Malaysia Building Integrated Photovoltaic (MBIPV) Project. The newly introduced Feed-In Tariff programme is presented in Section 3. Next, a loan-financial analysis on installations in Malaysia is presented in Section 4, indicating examples of other countries' financial support scheme. Conclusions are presented at the end of the paper. All the analysis in this paper is presented in Malaysia Ringgit (MYR) unless stated otherwise. For comparison, USD1.00 is approximately MYR3.00.

2. Energy outlook in Malaysia

2.1. Current energy demand in Malaysia

Malaysia is situated in the South East of Asia, comprising of two regions: West Malaysia and East Malaysia. It consists of thirteen states and three federal territories, and has a total area of 329, 847 km^2 [9]. Malaysia had a total population of more than 27 million in 2010 [10]. The gross domestic product (GDP) grew at a rate of 5.7% during the past six years [11], and the GoM has forecasted its economic growth to be between 5% and 6% in 2012 [12]. Similar to other developing countries, the increase in GDP and economic growth will directly influence the energy consumption demand in the nation [11]. In the Ninth Malaysia Plan [13], it was reported that the final commercial energy sector demand in Malaysia increased from 1243.7 PJ (Petajoules) in 2000 to 2217.9 PJ in 2010, an increment of close to 80%. The transport and industrial sectors continued to be the major energy consumers for the duration of 10 years, around 79.9% of the total energy in 2010, followed by the residential and commercial buildings sector at 12.8%, non-energy sector at 6.5% and agricultural and forestry sector for the remaining 0.8% [14]. Table 1 shows the final

[1] The figures for the world's energy consumption in [1] are written in British thermal units (Btu). 1 quadrillion Btu is equivalent to 1. Exajoules (EJ) in SI unit [2].

Table 1
Final commercial energy demand by sector in Malaysia (2000–2010) [13,14].

Source	Petajoules (PJ)						Average annual growth rate (%)	
	2000		2005		2010		Eighth Malaysia Plan	Ninth Malaysia Plan
Industrial[a]	477.6	(38.4%)	630.7	(38.6%)	859.9	(38.8%)	5.7	6.4
Transport	505.5	(40.6%)	661.3	(40.5%)	911.7	(41.1%)	5.5	6.6
Residential and commercial	162.0	(13.0%)	213.0	(13.1%)	284.9	(12.8%)	5.6	6.0
Non-energy[b]	94.2	(7.6%)	118.7	(7.3%)	144.7	(6.5%)	4.7	4.0
Agricultural and forestry	4.4	(0.4%)	8.0	(0.5%)	16.7	(0.8%)	12.9	15.9
Total	1243.7	(100.0%)	1613.7	(100.0%)	2217.9	(100.0%)	5.6	6.3

[a] Includes manufacturing, construction and mining.
[b] Includes natural gas, bitumen, asphalt, lubricants, industrial feedstock and grease.

commercial energy demand by sector in Malaysia from 2000 to 2010.

The same trend is also true for electricity demand in Malaysia. From 2000 to 2010, the electricity demand has doubled from 69,280 GW h to 137,909 GW h [13]. Electricity generation in Malaysia is largely produced from fossil fuels, mainly from natural gas and coal, which constitute nearly 90% of the overall generation [13], as illustrated in Fig. 2. In addition, Fig. 2 clearly illustrates that the electricity in Malaysia is fully dependent on fossil fuel sources. Although Malaysia is ranked 16th in terms of the size of its natural gas reserves [9], it is reported that the country could only sustain current natural gas production for about 29 years [15]. The supply for coal, on the other hand, is imported from outside of Malaysia, mainly from Indonesia (84%), Australia (11%) and South Africa (5%) [16].

This means that to sustain this increasing energy demand, while cutting the dependency on the fossil fuels, Malaysia needs to shift its energy generation to alternative energy resources.

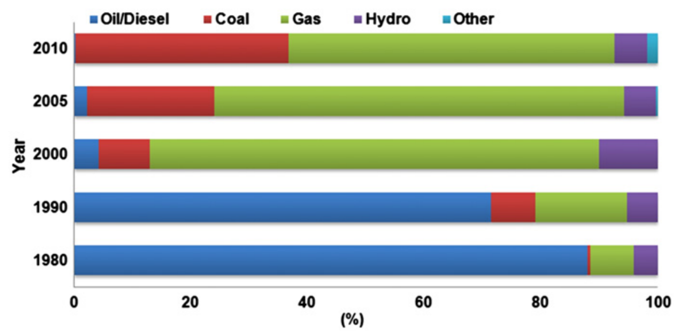

Fig. 2. Source of electricity in Malaysia. Adapted from [13,17].

2.2. National policy (1980–2010)

Since its independence, Malaysia has introduced more than ten policies and acts, which were closely related to the national energy development such as the National Depletion Policy 1980, Four Fuel Diversification Policy 1981, Electricity Supply Act 1990, Gas Supply Act 1993, Fifth Fuel Policy 2000, Energy Commission Act 2001, National Biofuel Policy 2006 and National Green Technology Policy [13,17–19]. Due to the scope of this paper, only policies related to solar energy will be discussed.

Before 1980, Malaysia relied greatly on oil as the primary source of electricity. In 1981, Malaysia introduced the Four Fuel Diversification Policy, in which hydro was listed as one of the contributors to the nation's energy mix 1981 [13]. As a result, twenty years later the dependency on oil was reduced greatly from about 90% in 1980 to only 4.2% in 2000, as shown in Fig. 2. Although hydro managed to supply around 10% of the electricity requirement in Malaysia, another 90% of the supply was still dominated by other non-renewable sources, i.e., coal and natural gas [18]. Oil is not considered a feasible source to generate electricity due to its fast depleting supply and its relatively high cost and thus, is mainly used as a back-up energy supply for emergencies [17]. In 2001, the GoM started to consider non-hydro renewable energy as one of the key sources of energy by implementing the Fifth Fuel Policy. This policy identified the potential in biomass, biogas, municipal waste, solar and mini hydro as sources of electricity generation. When this policy was introduced, it was aimed to generate 5% of electricity from renewable resources in five years' time [20]. Unfortunately, this target was not reached with only 0.3% of electricity being generated by renewable energy by the year 2005 [13]. General causes for slow renewable energy development include [21]: (i) market failure—there is only one buyer i.e., the national utility company called Tenaga National Berhad (TNB), which results in an unequal bargaining position of the utility and renewable energy project proponents; (ii) economic, financial and technological constraints which limits the performance of the market; (iii) absence of a legal framework which prevents proper and legal action from being taken, and (iv) lack of institutional measures to meet informational and technological needs.

In July 2009, the current Prime Minister of Malaysia, Datuk Seri Najib Tun Razak launched the new National Green Technology Policy [22]. The objectives of this policy include: (i) to minimise growth of energy consumption while enhancing economic development; (ii) to facilitate the growth of the Green Technology (GT) industry and enhance its contribution to the national economy; (iii) to increase national capability and capacity for innovation in GT development and enhance Malaysia's competitiveness in GT in the global arena; (iv) to ensure sustainable development and conserve the environment for future generations; and (v) to enhance public education and awareness on GT and encourage its widespread use. The policy will span for the next 15 years, covering three Malaysia Plans.

2.3. Solar PV as the main renewable energy

Although there is potential in biomass, biogas, municipal waste and mini hydro, solar PV has been identified as the energy source with the highest potential in satisfying the energy needs of Malaysia [23]. With a strategic geographical location, Malaysia benefits from a large quantity of solar insolation per year, ranging from 1400 to 1900 kW h/m^2/year [15], averaging about 1643 kW h/m^2/year [24] with more than 10 sun hours per day [25]. It was calculated theoretically that 1 kW p of solar panels installed in an area of 431 km^2 in Malaysia could generate enough electricity to satisfy the electricity requirements of the country in 2005 [24].

There are two types of solar PV connections; on-grid and off-grid. An on-grid connection simply means that there is interconnection between the building and the national grid, allowing any generated electricity from solar PV to be exported into the grid. This type of connection is normally associated with the Feed-in Tariff (FiT) scheme. An off-grid connection on the other hand does not have any link to the national grid. This type of configuration is normally connected to a storage bank such as battery, which will store the electricity and is suitable for remote places.

Solar PV can be designed to suit a variety of applications and operational requirements. The fuel (sunlight) is free and no noise or pollution is generated from its operation. A well designed and properly installed PV system will require minimal maintenance and has a longer service lifetime [11]. Given its potential, it is almost impossible not to tap into this resource for Malaysia's benefits, both in rural and urban areas. However, the main setback and uptake of deploying this technology is high cost of PV modules and equipment [11].

2.3.1. Solar PV in urban areas

To investigate the feasibility of solar PV in urban areas, the Malaysia Building Integrated Photovoltaic (MBIPV) Technology Application Project was launched on the 25th July 2005 [26]. The main objective of this programme was to reduce long-term cost of BIPV technology in Malaysia, which would lead to an increase in BIPV technology applications whilst reducing emissions of greenhouse gases. The MBIPV project focused on market development for BIPV technology and on building national capacity in three major areas: (i) policy and education; (ii) technical skill and market implementation, and (iii) technology development support.

At the early stages of the MBIPV project, a study which was conducted in May 2006 indicated that generating electricity in Malaysia from solar PV has the highest potential worldwide [27]. The main objective of this study was similar to another study conducted by the International Energy Agency (IEA) Photovoltaic Power Systems Programme (PVPS) Task 10 [28], which was "to enhance the opportunity for wide-scale solution-oriented application of PV in the urban environment as part of an integrated approach that maximizes building energy efficiency and solar thermal and PV usage". Selected cities in Malaysia, i.e., Kota Kinabalu, Penang, Kota Bharu, Kuching, Johor Bahru, Kuantan, Melaka and Kuala Lumpur, underwent similar measurement and the outcomes were compared to the result of the IEA-PVPS Task 10 study. The findings from the study were as the following [27,29]:

(i) the annual energy output for the selected Malaysian cities varies between 1170 and 1600 kW h/kW p for roof-top systems and between 630 and 830 kW h/kW p for facade systems. This places Malaysian cities among the top half for the annual energy output estimated for roof-top applications when compared to the 41 cities surveyed in [28].
(ii) the energy payback period ranges from 1.6 to 2.2 years and from 3 to 4 years for roof-top systems and facade systems, respectively. This is considerably shorter than the expected 30 years lifetime of the installations and thus the energy input for manufacturing and installation of PV systems can be recovered well before the end of its lifetime, and
(iii) the CO_2 mitigation ranges from 20 to 40 t of CO_2 for roof-top installations and from 10 to 20 t of CO_2 for facade systems for the duration of the system. Thus, CO_2 mitigation potential in Malaysia is relatively high.

The MBIPV project introduced three major incentives: (i) SURIA 1000 and SURIA for developers; (ii) demonstration, and (iii) showcase. Each incentive involved varying amounts of investment to incentivize the installation of BIPV technology as well as to accelerate the programme. This project ended on the 31st December 2010. As of May 2011, there are currently about 1652 kW p of solar PV capacity successfully installed and commissioned in four types of building—residential, commercial, industrial and school. Table 2 shows the breakdown of the installations according to building types in Malaysia. This 5-year project also managed to bring down the cost of PV greatly from MYR31410 per kW p in December 2005 to MYR19120 per kW p in March 2010, a reduction of about 40% of the cost. Currently, the price of solar PV has further reduced to MYR15000 per kW p [30]. Fig. 3 shows the average BIPV price per kW p from December 2005 until Jun 2011. The regression line indicates that the average price is reducing approximately MYR2221 per kW p per year.

2.3.2. Solar PV in rural areas

As for rural areas in Malaysia, most of these areas particularly in the East Malaysia region, still lack basic necessities such as the roads, electricity and clean water. The communities in these remote areas still depend largely on inefficient energy sources such as wood fuel and kerosene [31]. To provide electricity to these rural regions, the GoM launched the Rural Electrification Programme (REP) [32] which is under the responsibility of the Ministry of Rural and Regional Development. There are two options to provide electricity; (i) grid connection from sources supplied by the State Electricity Authorities for areas that are close to grid lines and (ii) alternative methods such as solar PV, generator sets or solar hybrid. Knowing the solar potential, every year the GoM has spent significant amounts of money on the provision of solar powered installations for rural and remote communities. In the Seventh Malaysia Plan (from 1996–2000) for example, the GoM spent about MYR156 million on this programme [33], which includes powering individual homes, longhouses, rural schools and clinics and islands. From 1997 onwards, all the Independent Power Producers (IPP) operating in West Malaysia together with Tenaga National Berhad (TNB) started to provide some funding to the REP. The money is pooled in a fund called the Malaysian Electricity Supply Industries Trust Account (MESITA) [34], managed by the Electricity Supply Industries Trust Account Committee. Subsequently, the Ministry of Education (MoE) initiated the Solar Hybrid System for Rural Schools in

Table 2
Total capacity of solar PV in Malaysia as of May 2011 [26].

Type of building	Number of installation	Total capacity installed (kW p)
Commercial	43	1022.27
Residential	70	490.36
Industrial	1	102.00
School	8	37.00
Total	122	1651.63

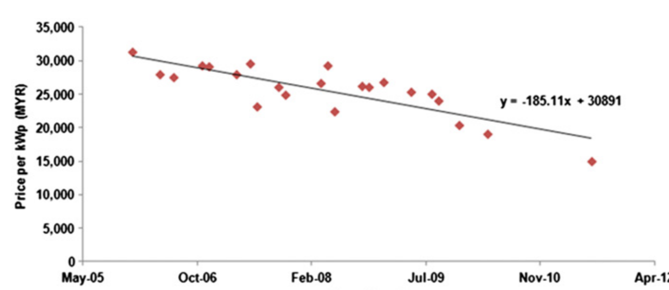

Fig. 3. Average BIPV price per kW p in Malaysia. Adapted from [26,30].

Sabah Project in 2008 aimed to electrify 78 rural schools [35]. By the end of 2010, the total off-grid solar PV and solar hybrid was estimated to have reached approximately 10 MW [36]. Table 3 shows the list of sites for off-grid solar PV and solar hybrid available in each state in Malaysia. During the recent Budget 2012 tabled by Malaysia's Prime Minister, an additional budget of MYR1.1 billion has been allocated for the rural area development programmes, which includes the REP and will be available starting in 2012 [12].

Table 3
The list of sites for off-grid solar PV and solar hybrid in Malaysia. Adapted from [37].

State	Number of sites
Sabah	52
Johor	13
Sarawak	7
Terengganu	3
Kelantan	3
Perak	2
Pahang	2
Kedah	1
Selangor	1
Total	84

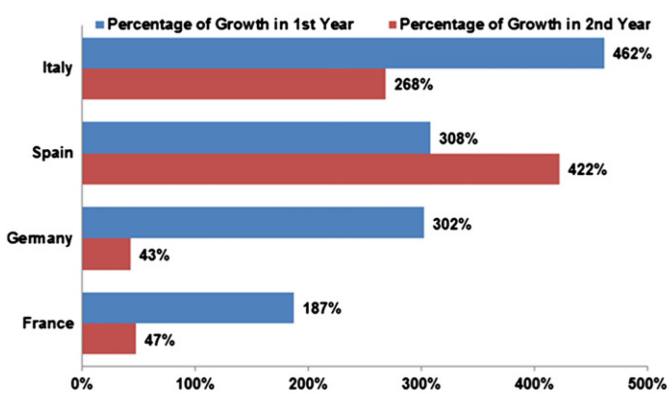

Fig. 4. Percentage change in annual installation levels in four European countries after the enactment of the FiT. Adapted from [39].

3. Renewable Energy Act 2011 and Feed-in Tariff in Malaysia

3.1. Overview of Feed-in Tariff

The FiT schemes, basically means renewable energy producers will be paid a set rate (tariff) for each unit of electricity fed into the grid, and generally obliges the power companies to purchase all the electricity from eligible producers in their service area over a long period of time—usually 15 to 20 years. As of 2011, the FiT has been enacted in 80 countries [8].

A research conducted by the Fraunhofer Institute for Systems and Innovation Research (ISI) published in 2010 [38] concluded that in most European countries with significant PV deployment, the vast majority of installations have occurred following the introduction of an FiT scheme. This is clearly indicated by strong growth of solar PV in Germany and Spain, until recently when the government of Spain amended its policies for solar. Recent tariff introductions in Italy, France, Portugal, Czech Republic and Slovenia have led to the stimulation of previously insignificant markets for PV. The FiT policies have led to the deployment of more than 15,000 MW of solar PV power between 2000 and 2009 in Europe [38]. In many European countries, the annual solar PV installation increased in excess of 300% in the first year of FiTs [39], as illustrated in Fig. 4. Globally, FiTs are responsible for approximately 75% of PV installations [38]. In 2010, solar PV was identified as the fastest growing renewable technology, followed by biodiesel and wind [8]. Grid-connected solar PV has an average annual growth of 81%, mainly driven by the feed-in tariff schemes [8].

Malaysia is convinced that FiT is the way forward to accelerate the growth of renewable energy. The 2011 document [40] states, "The Ministry of Energy, Green Technology and Water has conducted a thorough study on the effectiveness of the major renewable policy instruments practiced globally. The findings of the study showed that FiT is the most effective renewable energy policy mechanism in promoting and sustaining renewable energy growth." The FiT scheme was introduced in Malaysia by the Parliament passing the Renewable Energy Act 2011 (REA) in April [41]. As mentioned in the preamble to the REA, its creation is with

Table 4
The FiT rate for solar PV in Malaysia [41].

Renewable resource	Description of qualifying renewable energy installation	Feed-in Tariff Rate (MYR/kW h)	Effective Period -commencing from the feed-in tariff commencement date (year)	Annual degression rate (%)
Solar photovoltaic	(a) Renewable energy installation having an installed capacity of:	Basic feed-in tariff rate		
	(i) up to and including 4 kW	1.23	21	8.0
	(ii) above 4 kW, and up to and including 24 kW	1.20	21	8.0
	(iii) above 24 kW, and up to and including 72 kW	1.18	21	8.0
	(iv) above 72 kW, and up to and including 1 MW	1.14	21	8.0
	(v) above 1 MW, and up to and including 10 MW	0.95	21	8.0
	(vi) above 10 MW, and up to and including 30 MW	0.85	21	8.0
	(b) Renewable energy installation having any one or more of the following criteria in addition to (a) above:	Bonus feed-in tariff rate in addition to basic feed-in tariff rate		
	(i) use as installations in buildings or building structures	+0.26	21	8.0
	(ii) use as building materials	+0.25	21	8.0
	(iii) use of locally manufactured or assembled solar photovoltaic modules	+0.03	21	8.0
	(iv) use of locally manufactured or assembled solar inverters	+0.01	21	8.0

a specific purpose, which is to establish and implement a special tariff system or FiT to catalyze the generation of renewable energy from 2011 onwards. The feed-in tariff system will be administered and implemented by a new entity called the Sustainable Energy Development Authority (SEDA) created by its Act.

The FiT in Malaysia puts much emphasis on solar PV. In Malaysia's case, only two meter readings are required, these are the generation and the import meter. All the electricity generated will be exported to the national grid. Table 4 shows the rate for the amount of electricity generated using solar PV, ranging from MYR0.85 to MYR1.23 per kW h produced, depending on the installed capacity. Additional bonuses are also introduced on top of the basic FiT rate (ranging from MYR0.01 to MYR0.55 per kW h) when the installation meets specific criteria. It has a payback period of 21 years and the degression rate is 8% per year [41]. The launching date for the implementation of the FiT is scheduled for the 1st December 2011 [42].

Catalyzed by the FiT scheme, renewable energy sources are expected to play a significant role in Malaysia, with a projected cumulative capacity of 11.5 GW by 2050. From this, close to 9 GW is expected to come from solar PV, as illustrated in Fig. 5 [21]. However, to ensure that the FiT scheme works successfully in Malaysia, several issues must be effectively addressed by the law. These are: (i) the electricity generated must have guaranteed access to the grid; (ii) the local approval procedures have to be streamlined and clear; (iii) the FiT rate has to be high enough to generate sufficient returns and profit; (iv) the FiT rate is fixed for a long period for business certainty and security; (v) there has to be an adequate degression rate to achieve grid parity; (vi) there has to be sufficient fund created to pay the FiT rate for the whole contract period, and (vii) a competent agency is available to implement the FiT [43].

3.2. Is FiT a good investment?

A Malaysian household has an average monthly income of MYR4025 per month [10], where around 60% of them gain around MYR3500 or less [10]. A typical Malaysian household spends around MYR2190 monthly on various commodities and outputs, as shown in Fig. 6, where about 23% of the expenditure is spent to pay their utilities [10]. At the moment, Malaysia is one of the

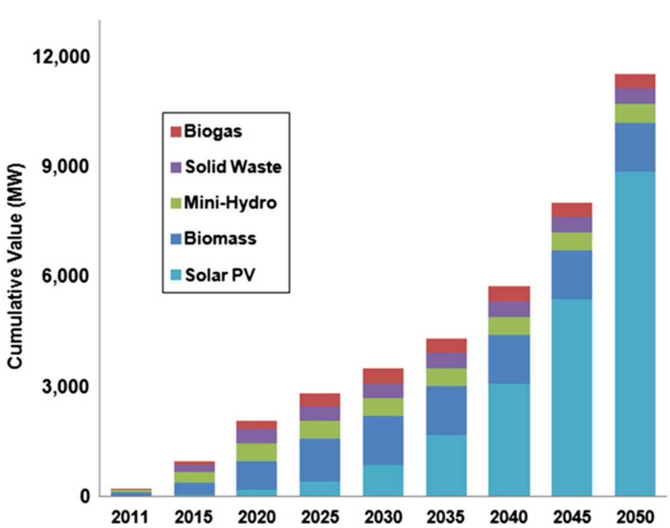

Fig. 5. Cumulative value of the renewable energies in Malaysia (2011–2050). Adapted from [21].

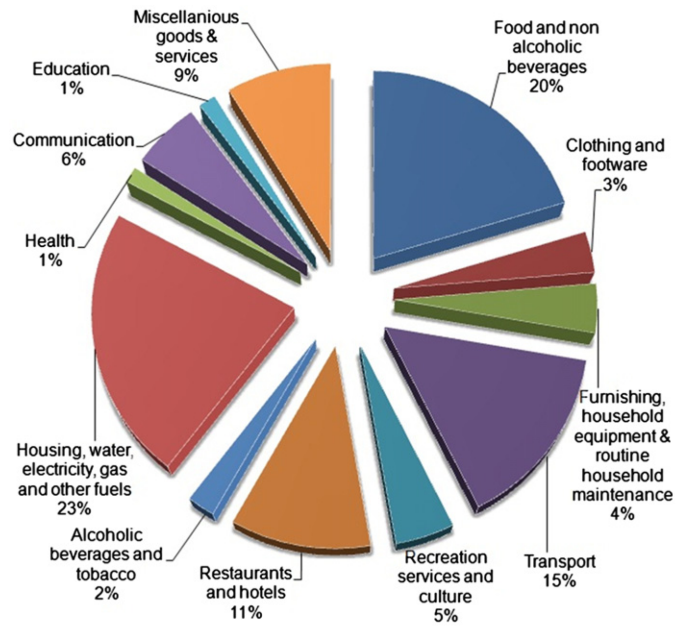

Fig. 6. Average household expenditure of a typical Malaysian. Adapted from [10].

countries with the highest household debt, about 75.9% of the GDP [44], where the largest proportion of the loan is for purchasing properties and vehicles [45]. The GoM has been working hard in order to turn Malaysia into a high-income nation by 2020 [46]; and a possible way to generate a stable extra monthly income from home is through the FiT, i.e., by installing solar panels on the rooftop.

As mentioned earlier, one of the requirements to implement the FiT is to ensure that the scheme generates a good return and a reasonable profit. Recently, a comparative financial study was conducted to analyse the viability of the FiT in Malaysia and other countries in the world [47]. This study assumed a 2.5 kW p PV panel installed in nine different world capitals, i.e., London (UK), Berlin (Germany), Rome (Italy), Washington D.C. (USA), Cape Town (South Africa), Tehran (Iran), Seoul (South Korea), Bangkok (Thailand) and Kuala Lumpur, (Malaysia). The study takes into account the PV cost in each country, the amount of solar insolation at each location and the rate of the FiT. It was assumed that the solar panel is fully paid for at the beginning of the installation. The study concluded that the FiT scheme in Malaysia is lucrative and could generate a reasonable return to the home owner, i.e., the second highest among the nine countries with an income of more than MYR100000 throughout the contract duration. In addition, it has the shortest payback period i.e., 10 years.

Another study was also carried out to analyse the return from a solar PV installation as a form of investment compared to other investment tools available in Malaysia [19]. Malaysians have the opportunity to invest in unit trusts, national unit trusts, Employee Provident Fund (EPF) government bonds, fixed deposits and savings accounts. This study, however, indicates that the FiT return is one of the lowest compared to most of the investment tools available in Malaysia, which further suggests that Malaysians might not be interested in considering solar PV as a form of investment.

Both studies ([19,47]) indicated that the high capital cost of solar PV systems make them unattractive amongst Malaysians. This is confirmed by a similar analysis [48] completed in 2009 which found that Malaysians will only invest in the solar PV systems if the cost is lower than MYR5500 per kW p; around a third of the current market price. As a solution to this, the GoM

through the Ministry of Energy, Green Technology and Water is proposing to provide financial assistance to start renewable energy projects, which includes solar PV installations [30,49].

4. Loan financing for solar PV

4.1. International practices

Together with the FiT, other financial incentives have proven to be crucial in accelerating the renewable energy penetration worldwide. Some of them include giving a subsidy for the initial capital cost of installation, providing soft loans with low interest rates and interest reduced mortgages for homes with PV as well as tax relief [50]. Germany for example, launched its 100,000 Roofs Programme (HTRP) for PV systems in 1999 [51]. To finance this project, the programme offered loans via German KfW (Kreditanstalt für Wiederaufbau, Reconstruction Loan Corporation) at a 0% interest rate for PV systems, and a waiver of the last instalment of up to 12.5% of the investment [52]. Initially, instead of 18 MW p PV systems, the programme only achieved around 50% of the target at the end of the first year, but this trend changed after the amendment on the Renewable Energy Sources Act (EEG) in April 2000 in which an FiT scheme was introduced [53,54]. Starting from February 2000, the number of applications to the HTRP rose dramatically and the installation reached 36 MW p by the end of that year. Due to the sharp increase in the financial loan applications for solar PV, the German KfW increased the loan interest rate to 1.9% in May 2000 and the payment of the last instalment was not remitted any longer [52]. The amount of the loan was also limited to €6900 per kW p for the first 5 kW p and to €3450 per kW p for every kW p exceeding 5 kW p [52]. Even with the changes in the guideline, the demand for solar PV financing was still high. In total, from 1999 to 2003, 45,858 PV systems with capacity of 345.5 MW p were subsidized in the HTRP, with total loans amounting to €1.72 billion [52].

In recent developments in Italy and Spain, two world-leading countries in terms of installed solar PV, secured massive investments from the Deutsche Bank [55]. The bank agreed to finance two solar PV parks, one in Canaro, Italy and another one in Toledo, Spain with a capacity of 48 MW p and 15.3 MW p, respectively. The total loan amount is approximately €160 million.

Similar to Germany, a FiT programme was enacted in Korea in 2004 [8], where the Korean Government introduced a 100,000 roof-top program to stimulate the local grid market [56]. To help this, the government provided a capital grant of up to 60% of the system cost for installation up to 3 kW p as well as a financial loan with very low interest [56]. These supported programs helped to boost the PV growth in Korea by six fold, from 13 MW in 2005 to 78 MW in 2007 [56].

Although there is no FiT scheme in New York, USA, the New York State Energy and Research Development Authority (NYSERDA) offers a cash incentive for home owners depending on the system size. A homeowner is eligible for an incentive of $4.00/watt, up to the first 5 kW installed, and declines to $3.00/watt for the next 5 kW, up to a limit of 10 kW [57]. An installation of a 6 kW p solar PV will enable the homeowner to get a payment of $23,000. On top of that, NYSERDA also offers an interest rate buy-down program to homeowners [57]. In this program, the homeowner enters into an agreement to borrow money from a bank to finance solar panel purchase. NYSERDA will make a one-time payment to the bank to bring down the borrower's interest rate by up to 4%. For example, if a bank is willing to lend money to a homeowner for a PV system at a rate of 8%, the interest rate will be reduced to 4% after the NYSERDA buy-down. Each homeowner could borrow up to $20,000 with a maximum tenure of 10 years [57]. As a result, New York is ranked 7th among the states in the USA in terms of grid-connected cumulative installation, reaching about 50 MW [58].

Table 5
Certified project under the GTFS as of 15 July 2011 [49].

Sector	2010		2011		Total
	User	Producer	User	Producer	
Building	1	1	2	2	6
Energy	10	25	7	16	58
Waste & Water	2	18	1	10	31
Transport	0	0	0	5	5
Total	13	44	10	33	100

The United Kingdom, which recently launched its own FiT scheme in April 2010, has seen a boom in solar PV installation. After five months since the launch of the FiT scheme, there were 3606 installation of PV in domestic houses, with a capacity of 8.457 MW [59]. To further accelerate the renewable energy penetration, the UK Government also plans to introduce a green investment bank with a total funding of £1 billion [60]. The proposed interest rate is between 5% and 6% [61]. A recent survey from Which? indicates that UK residents could gain as much as £10,500 over 25 years if they take a personal loan from commercial organizations such as Tesco, Sainsbury and the Post Office, where the loan interest could vary from 6% to 9%, depending on the loan period [62].

Malaysia also provides a number of fiscal incentives to help promote the usage of renewable technology. This includes the Green Technology Financing Scheme (GTFS), Pioneer Status (PS), Investment Tax Allowance (ITA), and exemption from payment of Import Duty and/or Sales Tax on machinery, equipment, materials, spare parts and consumables [18,23,63]. The most recent incentive consists of a soft loan scheme for residential consumers [30]. The next sections of this paper focus on the GTFS and the soft loan financing scheme for the individual household only.

4.2. Green Technology Financing Scheme for companies

To encourage the companies/commercial sectors to implement renewable technologies in Malaysia, the Green Technology Financing Scheme (GTFS) [49] was introduced in 2010 with a fund size of MYR1.5billion. This fund is expected to help companies that supply or utilize GT, with a maximum value of MYR10 million per consumer company and MYR50 million per producer company with the financing tenure of the fund being 10 years and 15 years respectively. There are four sectors of which companies could apply for which are: (i) building, (ii) energy, (iii) waste and water, and (iv) transport. The GoM will shoulder 2% of the total interest rate, as well as provide a guarantee of 60% on the financing amount via Credit Guarantee Corporation Malaysia Berhad (CGC), with the remaining 40% financing risk to be borne by participating financial institutions. As of July 2011, 100 GT project have been certified totalling to approximately MYR207 million in funding. Table 5 indicates the breakdown of the certified projects under the GTFS since its launch date.

4.3. Financing Scheme for Household Consumers

It is reported that the banking institutions in Malaysia are interested in providing loans to household consumers to purchase solar panels. The GoM is currently discussing with the Central Bank of Malaysia on creating specific guidelines which will be

used by all banking institutions. The GoM is proposing an interest rate ranging from 4% to 5% for the loan scheme [30].

It is normal practice for Malaysians to take loans from banks to finance their properties, vehicles, personal loans and credit card payments [45]. There are two types of interest rates available in Malaysia; fixed rate and floating rate [64]. The fixed rate value will remain the same throughout the loan tenure. The floating rate takes into account the difference between the base lending rate (BLR) of the financial institution and an 'agreeable' rate. For example, a bank could offer a rate of BLR 6.6% and an 'agreeable' rate of 2.5%; the effective interest rate of the loan will be 4.1%. The BLR will vary depending on the current economic status, and is contingent on the Overnight Policy Rate (OPR) determined by the Central Bank. The Central Bank of Malaysia requires that both the fixed and the floating rate must not exceed the value of 10% [64]. As of October 2011, the BLR of all banking institutions in Malaysia varies between 6.20% and 6.60% [64].

This section will analyze the impact of the interest rate on three things: the total profit generated over the period of FiT contract, the net present value (*NPV*) and the internal rate of return (*IRR*)[2] . The nomenclatures required for the financial analysis are available in Table 6. The total profit (P_T) is obtained by deducting the total cost (down payment (C_{DP}), total loan repayment (C_L), total cost of operation and maintenance ($C_{O\&M}$) and total cost of replacing the inverter ($C_{T\text{-INV}}$)) from the total revenue ($R_{T\text{-FiT}}$) generated from the FiT as illustrated in Eq. (1).

$$P_T = R_{T-\mathrm{FiT}} - (C_{\mathrm{DP}} + C_L + C_{\mathrm{O\&M}} + C_{\mathrm{INV}}) \quad (1)$$

To obtain the annual revenue generated from the FiT ($R_{\text{AN-FiT}}$), this is calculated by multiplying four parameters: the power rating of the PV panel (P_{PV}), the average yearly solar insolation (SI), the overall efficiency of the whole PV and the FiT rate (R_{FiT}) as indicated in Eq. (2). A 4 kW p solar panel is expected to cost around MYR60000 [30] while the inverter cost (C_{INV}) is MYR4500, and needs replacement every 10 years [65]. Taking into account the losses in the balance-of-the-system, the overall efficiency of the solar panel is assumed to be 0.75 [27]. To maximize the profit, the highest value of the FiT rate is chosen, i.e., MYR1.78[3] . The annual cost of O&M ($C_{\text{AN-O\&M}}$) is assumed to be 1% of the capital cost of the solar PV system (C_{PV}) [66]. Assuming the down payment for the loan is 10% of the capital cost, i.e., MYR6000, while the balance will be covered by the bank, the annual loan repayment ($C_{\text{AN-L}}$) is calculated using the compounding formula indicated in Eq. (3) [67], where the capital cost of solar PV, the loan interest rate (i) and the loan tenure (T_L) are taken into account. For the purpose of this analysis, the calculation will last for the duration of FiT contract, i.e., 21 years. The total profit must be a positive value and should be as high as possible to ensure that the investment generates a good income for the home owner. Table 6 shows all the parameters needed to calculate the value of the total profit.

$$R_{\mathrm{AN-FiT}} = P_{\mathrm{PV}} * \mathrm{SI} * (E_{\mathrm{EF}}) * (R_{\mathrm{FiT}}) \quad (2)$$

$$C_{\mathrm{AN}-L} = \frac{0.9 * C_{\mathrm{PV}} * (1+\mathrm{i})^{T_L}}{T_L} \quad (3)$$

The *NPV* is a measure which involves a series of cash flows for the lifetime of the solar PV system which enables the 'profits' to be seen [68]. It involves summing discounted future cash flow (CF), (in this case the net annual income), for the whole contract period (T_N), before deducting the initial capital investment, as illustrated in Eq. (4). The discounted rate, (r_d) chosen for this is selected to be 10%[4] [66]. In this case, the initial capital cost will be the down payment of the loan, i.e., MYR6000. A positive value of *NPV* indicates that the investment is feasible while a negative value implies that the investment should be discarded [68].

Table 6
The nomenclatures and parameters needed for the financial analysis.

Item	Abbreviation	Unit	Quantity
Annual cost of operation and maintenance	$C_{\text{AN-O\&M}}$	MYR	600
Annual loan repayment	$C_{\text{AN-}L}$	MYR	
Annual revenue generated from the FiT	$R_{\text{AN-FiT}}$	MYR	8,773.62
Average yearly solar insolation	SI	kW h/m^2/year	1,643
Capital cost of solar PV system	C_{PV}	MYR	60,000
Cash flow	CF	MYR	
Contract period	T_N	Year	21
Cost of operation and maintenance	$C_{O\&M}$	MYR	12,600
Cost of replacing one inverter	C_{INV}	MYR	4,500
Discounted rate	r_d	%	10
Down payment	C_{DP}	MYR	6,000
Efficiency	E_{EF}	-	0.75
FiT rate	R_{FiT}	MYR	1.78
Internal rate of return	*IRR*	%	>10
Loan interest rate	*i*	%	0 to 10
Loan tenure	T_L	Year	4 to 20
Net present value	*NPV*	MYR	>0
Solar PV system power rating	P_{PV}	kW p	4
Total cost of replacing the inverter	$C_{\text{T-INV}}$	MYR	9,000
Total loan repayment	C_L	MYR	
Total profit	P_T	MYR	>0
Total revenue	$R_{\text{T-FiT}}$	MYR	184,246.02

$$NPV = -\mathrm{CF}_0 + \sum_{T=1}^{N} \frac{\mathrm{CF}_T}{(1+r_d)^T} \quad (4)$$

As for the IRR, this can be defined as the growth rate of the project, which is found when the *NPV* value is equals to zero. For any solar PV installation, the proposed IRR value should be minimum 10%[5] [70]. In general, the higher the IRR, the more desirable the project becomes [71]. The formula for the IRR is shown in Eq. (5) and the polynomial equation can be solved either by using Newton–Raphson method or linear interpolation [72].

$$0 = -\mathrm{CF}_0 + \sum_{T=1}^{N} \frac{\mathrm{CF}_T}{(1+IRR)^T} \quad (5)$$

Tables 7 and 8 show the examples of the projected cash flow of a solar PV project, without and with loan financing respectively. If no loan is taken, the total profit is calculated to be MYR102646.02, the *NPV* is MYR8287.30 and the IRR is 11.97%. The payback period equals 6.96 years.

When a loan is considered, a series of scenarios are analyzed. The interest rate is varied between 0% and 10%, and the duration of the loan tenure is also investigated, ranging from 4 to 20 years. The detailed results of the total profit, *NPV* and *IRR* are available in the Appendix (Tables A.1–A.3). Fig. 7 shows the results of the analysis.

[2] The *IRR* in this paper is referring to nominal IRR. If the inflation rate is taken into account, the term is called real *IRR*, which is relatively lower than nominal *IRR*.

[3] This is only applicable when the installation is carried out until year 2013. An 8% degression rate is applicable from 2014 onwards.

[4] The discount rate chosen base on the IEA *Technology Roadmap-Solar Photovoltaic Energy* study which can be retrieved in [66]. A similar value of discount rate is used by in IEA *Energy Technology Perspectives 2010—Scenarios & Strategies to 2050* which is available in [69].

[5] The IRR value varies depending on the inflation rate. The study in [70] indicates that a 2% inflation rate could generate an IRR between 7% and 12%. To simplify the analysis, the mean value of the IRR is chosen, i.e., 10%.

Table 7
An example of the projected cash flow of the solar PV project without loan financing.

Year	Energy yield (kW h/kW p/year)	FiT rate (MYR)	Annual revenue from FiT (MYR)	Loan repayment (MYR)	O&M cost (MYR)	Replacement of inverter (MYR)	Net annual cash flow (MYR)	Cumulative cash flow (MYR)
1	4929.00	1.78	8,773.62	0.00	600.00		8,173.62	8,173.62
2	4929.00	1.78	8,773.62	0.00	600.00		8,173.62	16,347.24
3	4929.00	1.78	8,773.62	0.00	600.00		8,173.62	24,520.86
4	4929.00	1.78	8,773.62	0.00	600.00		8,173.62	32,694.48
5	4929.00	1.78	8,773.62	0.00	600.00		8,173.62	40,868.10
6	4929.00	1.78	8,773.62	0.00	600.00		8,173.62	49,041.72
7	4929.00	1.78	8,773.62	0.00	600.00		8,173.62	57,215.34
8	4929.00	1.78	8,773.62	0.00	600.00		8,173.62	65,388.96
9	4929.00	1.78	8,773.62	0.00	600.00		8,173.62	73,562.58
10	4929.00	1.78	8,773.62	0.00	600.00	4500.00	3,673.62	77,236.20
11	4929.00	1.78	8,773.62	0.00	600.00		8,173.62	85,409.82
12	4929.00	1.78	8,773.62	0.00	600.00		8,173.62	93,583.44
13	4929.00	1.78	8,773.62	0.00	600.00		8,173.62	101,757.06
14	4929.00	1.78	8,773.62	0.00	600.00		8,173.62	109,930.68
15	4929.00	1.78	8,773.62	0.00	600.00		8,173.62	118,104.30
16	4929.00	1.78	8,773.62	0.00	600.00		8,173.62	126,277.92
17	4929.00	1.78	8,773.62	0.00	600.00		8,173.62	134,451.54
18	4929.00	1.78	8,773.62	0.00	600.00		8,173.62	142,625.16
19	4929.00	1.78	8,773.62	0.00	600.00		8,173.62	150,798.78
20	4929.00	1.78	8,773.62	0.00	600.00	4,500.00	3,673.62	154,472.40
21	4929.00	1.78	8,773.62	0.00	600.00		8,173.62	162,646.02
		Total	184,246.02	0.00	12,600.00	9,000.00	162,646.02	162,646.02

Table 8
An example of the projected cash flow of the solar PV project with loan financing (3% interest rate and loan tenure of 9 years).

Year	Energy yield (kW h/kW p/year)	FiT rate (MYR)	Annual revenue from FiT (MYR)	Loan repayment (MYR)	O&M cost (MYR)	Replacement of inverter (MYR)	Net annual cash flow (MYR)	Cumulative cash flow (MYR)
1	4929.00	1.78	8,773.62	7,828.64	600.00		344.98	344.98
2	4929.00	1.78	8,773.62	7,828.64	600.00		344.98	689.96
3	4929.00	1.78	8,773.62	7,828.64	600.00		344.98	1,034.94
4	4929.00	1.78	8,773.62	7,828.64	600.00		344.98	1,379.92
5	4929.00	1.78	8,773.62	7,828.64	600.00		344.98	1,724.90
6	4929.00	1.78	8,773.62	7,828.64	600.00		344.98	2,069.89
7	4929.00	1.78	8,773.62	7,828.64	600.00		344.98	2,414.87
8	4929.00	1.78	8,773.62	7,828.64	600.00		344.98	2,759.85
9	4929.00	1.78	8,773.62	7,828.64	600.00		344.98	3,104.83
10	4929.00	1.78	8,773.62	0.00	600.00	4500.00	3,673.62	6,778.45
11	4929.00	1.78	8,773.62	0.00	600.00		8,173.62	14,952.07
12	4929.00	1.78	8,773.62	0.00	600.00		8,173.62	23,125.69
13	4929.00	1.78	8,773.62	0.00	600.00		8,173.62	31,299.31
14	4929.00	1.78	8,773.62	0.00	600.00		8,173.62	39,472.93
15	4929.00	1.78	8,773.62	0.00	600.00		8,173.62	47,646.55
16	4929.00	1.78	8,773.62	0.00	600.00		8,173.62	55,820.17
17	4929.00	1.78	8,773.62	0.00	600.00		8,173.62	63,993.79
18	4929.00	1.78	8,773.62	0.00	600.00		8,173.62	72,167.41
19	4929.00	1.78	8,773.62	0.00	600.00		8,173.62	80,341.03
20	4929.00	1.78	8,773.62	0.00	600.00	4,500.00	3,673.62	84,014.65
21	4929.00	1.78	8,773.62	0.00	600.00		8,173.62	92,188.27
		Total	184,246.02	70,457.75	12,600.00	9,000.00	92,188.27	92,188.27

Any interest rate of 5% or lower with a loan tenure ranging from 4 to 20 years is viable since it meets all the criteria of feasible investment. In general, the amount of total profit, the *NPV* and the *IRR* are higher if the interest rate is smaller. When the interest rate is 6%, the appropriate loan tenure will be 12 years maximum. A 7% interest rate is possible to take if the loan duration is a maximum of 8 years while an 8% interest rate is only feasible if the loan tenure is less than or equal to 6 years. If the chosen rate is 9%, the tenure must be less than or equal to 4 years. No loan should be taken if the interest rate is 10%.

Based on these calculations, the proposed interest rate of 4% to 5% by the GoM is considered feasible for Malaysian context. However, if the GoM is serious about promoting solar as the main RE, it is also advisable to perhaps propose an even lower interest rate, maybe between 2% and 3%. The loan tenure also must be a maximum 10 of years, to ensure that the return gain by the home owner is as high as possible. This will enable the home owner to gain a total profit of about MYR84000 to MYR98000 for the duration of 21 years. With a MYR6000 down payment, an interest rate of 2% for a tenure of 10 years will generate an extra cash flow of MYR133 a month for the first 10 years and about MYR681 a month for the next 11 years. This can act not only as the catalyst to increase solar energy penetration, but also as a tool to increase Malaysians' monthly income hence helping in achieving Malaysia's target of becoming a high-income nation.

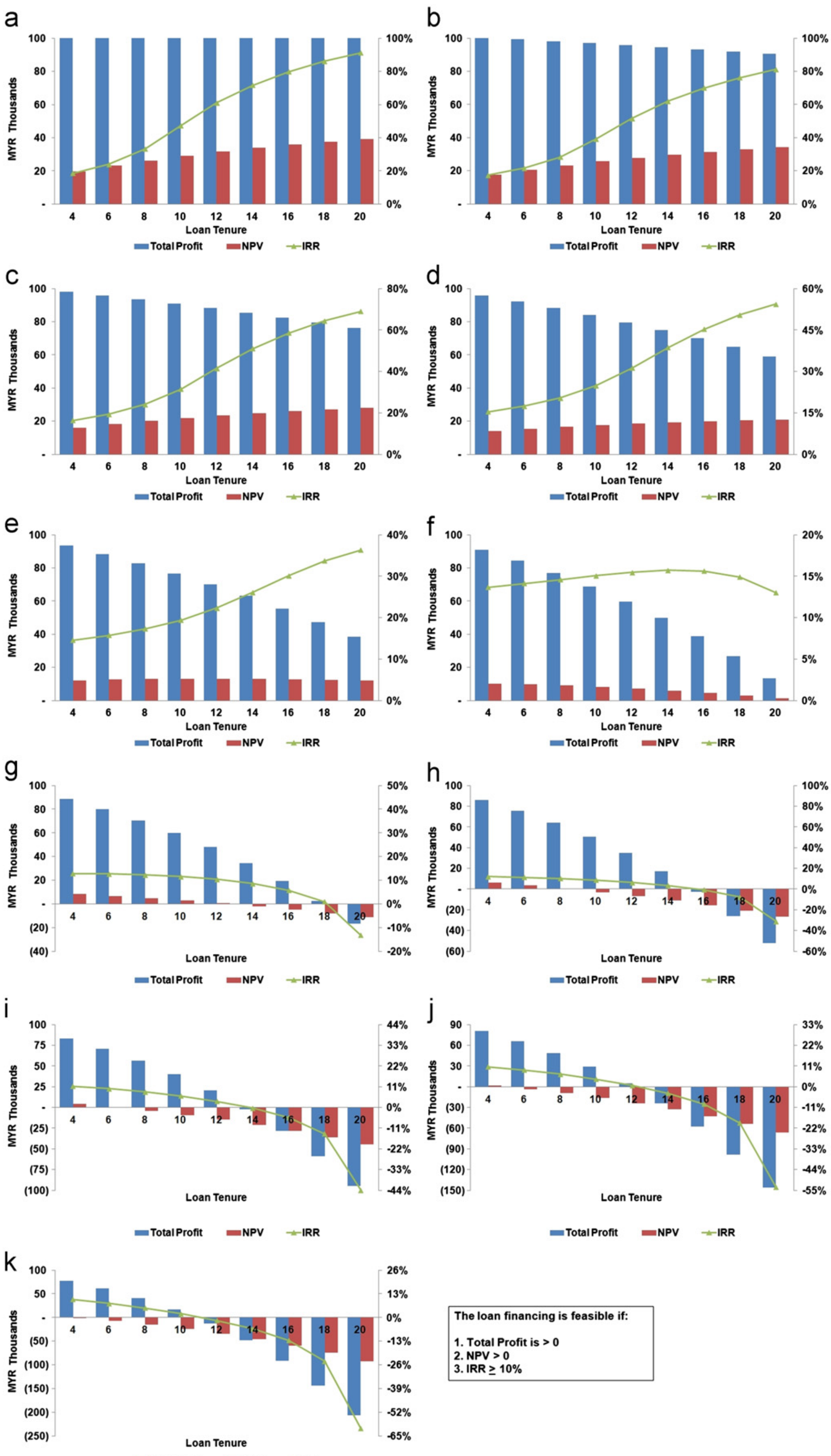

Fig. 7. Analysis of the effect of various interest rates on the total profit, the *NPV* and the *IRR* using different loan tenure. The interest rate is (a) 0%, (b) 1%, (c) 2%, (d) 3%, (e) 4%, (f) 5%, (g) 6%, (h) 7%, (i) 8%, (j) 9% and (k) 10%.

However, the GoM must ensure that the public is aware of this financing incentive, since some studies indicate that general Malaysian awareness level relating to renewable energy is still very low [19,48]. Without proper awareness schemes, people might not choose to invest, particularly if this means taking more loans from the bank, on top of their existing loans for properties and vehicles [45]. Another important point is to relax the requirement on applying for solar PV loans. This is because; the installation of PV is considered a low-risk investment, with guaranteed returns [70]. Hence it is highly unlikely for borrowers to default on loan repayments.

5. Conclusions

1. Solar energy has significant potential for suplementing energy requirement in Malaysia. The GoM has proposed a number of policies to increase the renewable energy penetration in Malaysia, particularly for solar PV. From 2005 until 2010, the MBIPV project was the driving force to accelerate solar PV penetration in Malaysia.
2. The recent introduction of the FiT scheme is likely to become the key driver to further boost the solar PV industry in Malaysia; this has already successfully happened in Germany, Italy and the UK. It has been calculated that the FiT rate in Malaysia generates reasonable revenue and profit, but additional financing support schemes will be required to start implementing solar PV installations, due to high initial costs.
3. The GoM has introduced a number of additional financial support schemes. GTFS is a good financial source for companies to invest in solar PV. As for individual homeowners, a soft loan from banking institution is feasible if the interest rate is 5% or less.
4. However, based on recent surveys that were conducted in [19] and [48], they concluded that Malaysians have a low level of understanding of the numerous incentives, despite the fact that the solar PV industry has shown an increase in terms of the number of installations. With low levels of awareness on renewable energy policies in Malaysia, it is not surprising that Malaysians would not want to invest in renewable energy. This appears to be one of the major barriers for the FiT scheme—especially solar PV.
5. It is recommended that the GoM, together with the private sector, (i) provide sufficient awareness about renewable technology and financial incentives (FiT and the green financing scheme) via the mass media and other outlets, (ii) create a low interest rate loan, perhaps between 2% and 3% with a shorter loan tenure of maximum 10 years, to accelerate the solar PV installation (as shown by positive developments in Germany, Korea and the UK), and (iii) relax the requirements to apply for the loan. If these measures take place, it might be possible to see high penetration of renewable energy in Malaysia.

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Appendix

See Tables A.1–A.3.

Table A.1
Total profit (in MYR) for the solar PV installation under various loan interest rate and different loan tenure.

Loan tenure (year)	Interest rate (%)										
	0.00	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
4	102,646.02	100,453.40	98,194.68	95,868.54	93,473.66	91,008.68	88,472.26	85,863.04	83,179.62	80,420.61	*77,584.62*
6	102,646.02	99,323.93	95,833.25	92,167.20	88,318.79	84,280.86	80,045.99	75,606.58	70,954.81	*66,082.61*	*60,981.73*
8	102,646.02	98,171.76	93,376.41	88,240.44	82,743.29	76,863.43	70,578.22	63,863.97	*56,695.79*	*49,047.64*	*40,892.22*
10	102,646.02	96,996.43	90,820.32	84,074.54	76,712.83	68,685.71	59,940.24	*50,419.85*	*40,064.07*	*28,808.38*	*16,583.93*
12	102,646.02	95,797.47	88,160.96	79,654.93	70,190.28	59,669.78	47,987.41	*35,027.67*	*20,664.83*	*4,762.12*	*(12,829.11)*
14	102,646.02	94,574.41	85,394.17	74,966.17	63,135.49	49,729.71	*34,557.21*	*17,405.18*	*(1,962.44)*	*(23,807.24)*	*(48,418.89)*
16	102,646.02	93,326.77	82,515.59	69,991.87	55,505.03	38,770.79	*19,467.03*	*(2,770.82)*	*(28,354.88)*	*(57,750.50)*	*(91,482.52)*
18	102,646.02	92,054.06	79,520.72	64,714.63	47,251.93	26,688.58	*2,511.71*	*(25,870.32)*	*(59,139.03)*	*(98,078.48)*	*(143,589.51)*
20	102,646.02	90,755.76	76,404.86	59,116.01	38,325.37	13,367.94	*(16,539.30)*	*(52,316.94)*	*(95,045.67)*	*(145,992.16)*	*(206,638.98)*

Note: Italicized values indicate that the loan initiatives are not feasible to finance the solar PV installation.

Table A.2
The *NPV* (in MYR) for the solar PV installation under various loan interest rate and different loan tenure.

Loan tenure (year)	Interest rate (%)										
	0.00	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
4	19,494.12	17,756.54	15,966.58	14,123.19	12,225.33	10,271.92	8,261.89	6,194.17	4,067.65	1,881.23	*(366.20)*
6	23,089.95	20,678.53	18,144.72	15,483.62	12,690.15	9,759.11	6,685.11	3,462.65	86.04	*(3,450.57)*	*(7,153.19)*
8	26,276.55	23,292.82	20,094.96	16,669.96	13,004.10	9,083.02	4,891.63	414.12	*(4,366.09)*	*(9,466.38)*	*(14,904.95)*
10	29,106.64	25,635.21	21,840.26	17,695.26	13,171.81	8,239.50	2,865.79	*(2,984.09)*	*(9,347.26)*	*(16,263.40)*	*(23,774.79)*
12	31,625.69	27,737.03	23,400.96	18,571.17	13,197.07	7,223.45	590.11	*(6,768.53)*	*(14,923.86)*	*(23,953.54)*	*(33,941.98)*
14	33,872.93	29,625.72	24,795.15	19,308.02	13,082.81	6,028.80	*(1,954.85)*	*(10,980.11)*	*(21,171.19)*	*(32,665.76)*	*(45,616.21)*
16	35,882.28	31,325.34	26,038.87	19,915.00	12,831.20	4,648.46	*(4,790.73)*	*(15,664.63)*	*(28,174.77)*	*(42,548.69)*	*(59,043.04)*
18	37,683.06	32,857.00	27,146.39	20,400.23	12,443.63	3,074.27	*(7,941.54)*	*(20,873.35)*	*(36,031.71)*	*(53,773.85)*	*(74,510.22)*
20	39,300.68	34,239.25	28,130.39	20,770.90	11,920.78	1,296.95	*(11,433.91)*	*(26,663.67)*	*(44,852.36)*	*(66,539.17)*	*(92,355.20)*

Note: Italicized values indicate that the loan initiatives are not feasible to finance the solar PV installation.

Table A.3
The *IRR* (in percentage) for the solar PV installation under various loan interest rate and different loan tenure.

Loan tenure (year)	Interest rate (%)										
	0.00	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
4	18.49	17.42	16.41	15.45	14.54	13.67	12.84	12.06	11.30	10.58	*9.89*
6	23.87	21.53	19.41	17.48	15.73	14.12	12.65	11.29	10.03	*8.86*	*7.76*
8	33.23	28.34	24.08	20.43	17.29	14.59	12.24	10.17	*8.33*	*6.67*	*5.17*
10	47.31	39.20	31.54	24.87	19.42	15.06	11.53	*8.60*	*6.12*	*3.98*	*2.08*
12	61.07	51.65	41.50	31.28	22.33	15.47	10.37	*6.45*	*3.31*	*0.67*	*(1.61)*
14	71.73	62.04	51.01	38.70	26.08	15.71	*8.56*	*3.52*	*(0.33)*	*(3.48)*	*(6.17)*
16	79.81	70.02	58.61	45.31	30.15	15.63	*5.76*	*(0.64)*	*(5.36)*	*(9.20)*	*(12.51)*
18	86.10	76.22	64.48	50.49	33.71	14.92	*0.98*	*(7.58)*	*(13.94)*	*(19.27)*	*(24.00)*
20	91.12	81.16	69.09	54.41	36.34	13.01	*(13.18)*	*(31.24)*	*(43.88)*	*(53.39)*	*(60.90)*

Note: Italicized values indicate that the loan initiatives are not feasible to finance the solar PV installation.

References

[1] U.S. Energy Information Administration (EIA), 2011. International Energy Outlook 2011, U.S. EIA, Washington DC, USA. (Last accessed on) [10/10/2011]. Available from 〈www.eia.gov/ieo/pdf/0484(2011).pdf〉.
[2] American Physical Society (APS) Sites, 2011. Energy Units APS Sites. (Last accessed on) [14/10/2011]. Available from 〈http://www.aps.org/policy/reports/popa-reports/energy/units.cfm〉.
[3] Ab Kadir MZA, Rafeeu Y, Adam NM. Prospective scenarios for the full solar energy development in Malaysia. Renewable and Sustainable Energy Reviews 2010;14(9):3023–31.
[4] Abbott D. Keeping the energy debate clean: how do we supply the world's energy Needs? Proceedings of the IEEE 2010;98(1):42–66.
[5] Choi CQ. 2011. Gulf Oil Spill Paves Way for Alternative Energy Push, LiveScience. (Last accessed on) [17/01/2011]. Available from 〈http://www.livescience.com/environment/oil-spill-alternative-energy-100610.html〉.
[6] Grimston, M. 2010. Fukushima: What Happened - And What Needs To Be Done, BBC, UK. (Last accessed on) [10/10/2011]. Available from 〈http://www.bbc.co.uk/news/world-asia-pacific-13017282〉.
[7] Clover R, Knight Z, Robins, N, Saravanan D. 2011. Climate Investment Update - Japan's Nuclear Crisis and the Case for Clean Energy, HSBC Global Research. (Last accessed on) [10/10/2011]. Available from 〈http://www.research.hsbc.com/midas/Res/RDV?ao=20&key=4wVf4k0yKe&n=293732.PDF〉.
[8] Renewable Energy Policy Network for the 21st Century (REN21), 2011. "Renewables 2011 Global Status Report", REN21, Paris. (Last accessed on) [10/10/2011]. Available from 〈http://www.ren21.net/Portals/97/documents/GSR/REN21_GSR2011.pdf〉.
[9] Central Intelligence Agency (CIA) 2011. The World FactBook, CIA. (Last accessed on) [17/01/2011]. Available from 〈https://www.cia.gov/library/publications/the-world-factbook/geos/my.html〉.
[10] Department of Statistics Malaysia, 2011. (Last accessed on) [17/01/2011]. Available from 〈http://www.statistics.gov.my/〉.
[11] Ong HC, Mahlia TMI, Masjuki HH. A review on energy scenario and sustainable energy in Malaysia. Renewable and Sustainable Energy Reviews 2011;15(1):639–47.
[12] Ministry of Finance Malaysia, 2011. "The 2012 Budget Speech", Government of Malaysia, Malaysia, (Last accessed on) [11/10/2011]. Available from 〈http://www.treasury.gov.my/pdf/budget/bs12.pdf〉.
[13] Economic Planning Unit, 2006. Ninth Malaysia Plan 2006–2010, Economic Planning Unit, Putrajaya, Malaysia.
[14] Chua SC, Oh TH. Review on Malaysia's national energy developments: key policies, agencies, programmes and international involvements. Renewable and Sustainable Energy Reviews 2010;14(9):2916–25.
[15] Ahmad S, Kadir MZAA, Shafie S. Current perspective of the renewable energy development in Malaysia. Renewable and Sustainable Energy Reviews 2011;15(2):897–904.
[16] Jaffar AJ. Outlook of Coal Demand/Supply & Policy in Malaysia. South Korea: Cleaner Coal: Moving Towards Zero Emissions, APEC, Incheon; 2009.
[17] Oh TH, Pang SY, Chua SC. Energy policy and alternative energy in Malaysia: issues and challenges for sustainable growth. Renewable and Sustainable Energy Reviews 2010;14(4):1241–52.
[18] Chua SC, Oh TH. Green progress and prospect in Malaysia. Renewable and Sustainable Energy Reviews 2011;15(6):2850–61.
[19] Muhammad-Sukki F, Ramirez-Iniguez R, Abu-Bakar SH, McMeekin SG, Stewart BG. An Evaluation of the Installation of Solar Photovoltaic in Residential Houses in Malaysia: Past, Present and Future, Energy Policy, 39, 12, 7975–7987.
[20] Leo-Moggie A. Keynote Address. Kuala Lumpur, Malaysia: Malaysia Regional Forum on Energy Policy for the New Millenium; 2001.
[21] Abdul Malek B. 2010. Renewable Energy Development in Malaysia, 34th Expert Group on New and Renewable Energy Technologies (EGNRET), Kuala Lumpur, Malaysia, pp. 1-46.
[22] Ministry of Energy, Green Technology and Water, 2011. National Green Technology Policy Objective, Government of Malaysia, Malaysia. (Last accessed on) [11/10/2011]. Available from 〈http://www.kettha.gov.my/en/content/national-green-technology-policy-objective〉.
[23] Chua SC, Oh TH. Solar Energy Outlook in Malaysia, Renewable and Sustainable Energy Reviews, 16, 1, 564–574.
[24] Haris AH. MBIPV Project: Catalyzing Local PV Market. Kuala Lumpur, Malaysia: Finance & Investment Forum on PV Technology; 2008.
[25] Amin N, Lung CW, Sopian K. A practical field study of various solar cells on their performance in Malaysia. Renewable Energy 2009;34(8):1939–46.
[26] MBIPV Project. 2010. (Last accessed on) [31/12/2010]. Available from 〈http://www.mbipv.net.my/〉.
[27] MBIPV Project. 2006. Compared Assessment of Selected Environmental Indicators of PV Electricity in Selected OECD Cities and Malaysian Cities, MBIPV Project, Malaysia. (Last accessed on) [11/10/2011]. Available from 〈http://www.mbipv.net.my/dload/MBIPV%20Reports/C3/Compared%20Assmnt%20of%20Selected%20Environmental%20Indicators%20of%20PV%20(.pdf〉.
[28] IEA-PVPS, 2006. Compared Assessment of Selected Environmental Indicators of Photovoltaic Electricity in OECD Cities, Report IEA-PVPS T10-01:2006, IEA-PVPS. (Last accessed on) [11/10/2011]. Available from 〈http://www.iea-pvps-task10.org/IMG/pdf/report_IEA-PVPS_T10-01-2006.pdf〉.
[29] Chua SC, Oh TH, Goh WW. Feed-in tariff outlook in Malaysia. Renewable and Sustainable Energy Reviews 2011;15(1):705–12.
[30] Bernama. Malaysia Looking at Soft Loans for Household Solar Purchases. Kuala Lumpur, Malaysia: Bernama; 2011.
[31] United Nations Development Programme (UNDP), 2007. Energy and Poverty in Malaysia: Challenges and the Way Forward, UNDP Regional Centre, Bangkok, Thailand. (Last accessed on) [14/10/2011]. Available from 〈http://regionalcentrebangkok.undp.or.th/practices/energy_env/rep-por/documents/GAP_Reports/Malaysia.pdf〉.
[32] Ministry of Rural and Regional Development, 2011. Electricity, Government of Malaysia, Malaysia. (Last accessed on) [14/10/2011]. Available from 〈http://www.rurallink.gov.my/electricity〉.
[33] Ministry of Energy, Green Technology and Water, 2011. Solar Energy, Government of Malaysia, Malaysia. (Last accessed on) [11/10/2011]. Available from 〈http://www.kettha.gov.my/en/content/solar-energy〉.
[34] Ministry of Energy, Green Technology and Water, 2010. Malaysian Electricity Supply Industries Trust Account (MESITA), Government of Malaysia, Malaysia. (Last accessed on) [14/10/2011]. Available from 〈http://www.kettha.gov.my/en/content/malaysian-electricity-supply-industries-trust-account-mesita〉.
[35] Mahmud AM. 2010. Evaluation of the Solar Hybrid System for Rural School in Sabah, Malaysia, IEEE International Conference on Power and Energy, 29 November – 1 December 2010, Kuala Lumpur, Malaysia, pp. 628–633.
[36] Haris AH. Malaysia's Latest Solar PV Market Development, Clean Energy Expo Asia 2010. Singapore: CEEA, SUNTEC; 2010 pp. 1–32.
[37] Idris N, Omar AM, Shaari S. 2010. Stand-Alone Photovoltaic Power System Applications in Malaysia, 4th International Power Engineering and Optimization Conference, 23–24 June 2010, Shah Alam, Selangor, Malaysia, pp. 474–479.
[38] Ragwitz M, Held A, StrickerE, Krechting A, Resch G, Panzer C. 2010. Recent Experiences with Feed-in Tariff Systems in the EU—A Research Paper for the International Feed-in Cooperation, International Feed-In Cooperation, Europe. (Last accessed on) [11/10/2011]. Available from 〈http://www.feed-in-cooperation.org/wDefault_7/download-files/8th-workshop/IFIC_feed-in_evaluation_Nov_2010.pdf〉.
[39] PriceWaterCoopers (PwC), 2010. On the Brink of a Bright Future? Insight on the UK Solar Photovoltaic Market, PwC, United Kingdom. Last accesses on [14/10/2011]. Available from 〈http://www.ukmediacentre.pwc.com/imagelibrary/downloadMedia.ashx?MediaDetailsID=1748〉.
[40] Ministry of Energy, Green Technology and Water, 2011. Handbook on the Malaysian Feed-in Tariff for the Promotion of Renewable Energy, Government of Malaysia, Malaysia, (Last accessed on) [11/10/2011]. Available from 〈www.mbipv.net.my/dload/FiT%20Handbook%20English.pdf〉.

[41] Government of Malaysia, Malaysia. Renewable Energy Act 2011. Malaysia: Government of Malaysia; 2011.
[42] Kui PCF. 2011. Minister of Energy, Green Technology and Water Announces Revised Launching Date for the Implementation of Feed-In Tariff System, Press Release, 15/08/ 2011, Putrajaya, Malaysia.
[43] Haris AH. 2009. Feed-in Tariff (FiT): Driving Forward Green Technologies & Deployments, 2nd National Photovoltaic Conference (2009), Putrajaya, Malaysia, pp. 1–24.
[44] Bank Negara Malaysia (BNM), 2011. Annual Report 2010, BNM, Malaysia. (Last accessed on) [14/10/2011]. Available from 〈www.bnm.gov.my/files/publication/ar/en/2010/ar2010_book.pdf〉.
[45] Endut N, Hua TG. Household debt in Malaysia. BIS Papers No 2009;46: 107–16.
[46] Economic Transformation Programme, 2011. (Last accessed on) [11/10/2011]. Available from 〈http://etp.pemandu.gov.my/〉.
[47] Muhammad-Sukki F, Ramirez-Iniguez R, Abu-Bakar S, McMeekin, SG, Stewart, BG, Chilukuri MV. 2011. Feed-In Tariff for Solar PV in Malaysia: Financial Analysis and Public Perspective, 5th International Power Engineering and Optimization Conference, 6–7 June 2011, Shah Alam, Selangor, Malaysia, pp. 221–226.
[48] Haw LC, Sopian K, Sulaiman K, Hafidz M, Yahya M. Assessment of public perception on photovoltaic application in Malaysia Urban residential areas using trudgill's framework for analysis. European Journal of Social Sciences 2009;8(4):589–603.
[49] Green Technology Financing Scheme, 2011. Available at 〈http://www.gtfs.my/node/27〉. (Last accessed) [13/10/2011].
[50] Weiss I, Orthen S, Stierstorfer J., Gisler R. 2006. European Best Practice Report, PV Policy Group, Europe. (Last accessed on) [14/10/2011]. Available from 〈http://www.pvpolicy.org/documents/PVPolicyEuropeanBestPracticeReport_id205.pdf〉.
[51] Weiss, I, Sprau P, Helm P. 2003. The German PV Solar Power Financing Schemes Reflected on the German PV Market, 3rd World Conference on Photovoltaic Energy Conversion, 11–18 May 2003, Osaka, Japan, vol. 3, pp. 2592- 2595.
[52] Stryi-Hipp G, 2004. The Effects of the German Renewable Energy Sources Act (EEG) on Market, Technical and Industrial Development, 19th European Photovoltaic Solar Energy Conference, 7–11 June 2004, Paris.
[53] Wagner H, Hunnekes C. 2002. PV Programs in Germany, 29th IEEE Photovoltaic Specialists Conference, 21–24 May 2002, New Orleans, Louisiana, USA, pp. 32–33.
[54] Varma RK, Sanderson G, Walsh K. 2011. Global PV Incentive Policies and Recommendations for Utilities, 24th Canadian Conference on Electrical and Computer Engineering, 5–8 May 2011, Niagara Falls, Ontario, Canada, pp. 001158–001163.
[55] Rogerson B. 2011. Deutsche Bank heads major PV funding for Italy and Spain, AssetFinanceInternational. (Last accessed on) [14/10/2011]. Available from 〈http://www.assetfinanceinternational.com/index.php?option=com_content&view=article&id=4355:deutsche-bank-heads-major-pv-funding-for-italy-and-spain&catid=702:europe&Itemid=1227〉.
[56] Watt M. 2009. Assessment of the Future Costs and Performance of Solar Photovoltaic Technologies in New Zealand, Australia. (Last accessed on) [14/10/2011]. Available from 〈http://www.med.govt.nz/upload/67238/PV%20in%20New%20Zealand.pdf〉.
[57] Coughlin J, Cory K. 2009. Solar Photovoltaic Financing: Residential Sector Deployment, Technical Report NREL/TP-6A2-44853, National Renewable Energy Laboratory (NREL), USA. (Last accessed on) [14/10/2011]. Available from 〈www.nrel.gov/docs/fy09osti/44853.pdf〉.
[58] Sherwood L. 2011. U.S. Solar Market Trend 2010, Interstate Renewable Energy Council (IREC), USA. (Last accessed on) [14/10/2011]. Available from 〈http://www.irecusa.org/wp-content/uploads/2011/06/IREC-Solar-Market-Trends-Report-June-2011-web.pdf〉.
[59] Department of Energy and Climate Change (DECC). Energy Trends September 2010. United Kingdom: DECC; 2010.
[60] Press. 2010, £1 billion to Launch Green Investment Bank, The Independent, United Kingdom. (Last accessed on) [14/10/2011]. Available from 〈http://www.independent.co.uk/news/uk/politics/1-billion-to-launch-green-investment-bank-2111807.html〉.
[61] Brignall M, 2010. Solar Panels the Hot New Items as Pas-As-You-Save Launches, The Guardian, UK. (Last accessed on) [14/10/2011]. Available from 〈http://www.guardian.co.uk/money/2010/mar/06/solar-panels-pay-as-you-save〉.
[62] Which?, 2010. 'Free' solar panels not such a great deal, Which?, UK. (Last accessed on) [14/10/2011]. Available from 〈http://www.which.co.uk/news/2010/09/free-solar-panels-not-such-a-great-deal-231808/〉.
[63] Ministry of Energy, Green Technology and Water, 2009. Incentives for Renewable Energy and Energy Efficiency in Malaysia, Government of Malaysia, Malaysia. (Last accessed on) [11/10/2011]. Available from 〈http://seda.gov.my/pdf/PTM%20Incentives.pdf〉.
[64] Banking Info Malaysia, 2011. (Last accessed on) [11/10/2011]. Available from 〈http://www.bankinginfo.com.my/〉.
[65] Gading Kencana Sdn. Bhd. 2011. Generate an Income by Using Solar. (Last accessed on) [14/10/2011]. Available at 〈http://www.gadingkencana.com.my/〉.
[66] IEA. 2010. Technology Roadmaps—Solar Photovoltaic Energy. IEA, Paris, France. (Last accessed on) [14/10/2009]. Available from 〈www.iea.org/papers/2010/pv_roadmap.pdf〉.
[67] Marecka E. 2001. Informational and Analytical System for Support of Financial and Credit Activity, International Workshop on Intelligent Data Acquisition and Advanced Computing Systems: Technology and Applications, 1–4 July 2001, Crimea, Ukraine, pp. 263–266.
[68] Sudtharalingam S, Hawkes, AD, Green TC. Feasibility of Domestic Micro Combined Heat and Power Units with Real Time Pricing, IEEE Power & Energy Society (PES) General Meeting, 25–29 July 2010, Minneapolis, USA, pp. 1–8.
[69] IEA. 2010. Energy Technology Perspectives 2010—*Scenarios & Strategies to 2050*. IEA, Paris, France. (Last accessed on) [14/10/2011]. Available from 〈http://www.iea.org/publications/free_new_Desc.asp?PUBS_ID=2100〉.
[70] Ownergy. 2011. The Personal Investment Guide to the Feed-in Tariff, Ownergy, UK. (Last accessed on) [14/10/2009]. Available from 〈http://www.ownergy.co.uk/library/info/personal_investment_guide_FINAL.pdf〉.
[71] Investopedia. 2011. (Last accessed on) [14/10/2009]. Available from 〈http://www.investopedia.com/〉.
[72] Think&Done. 2011. Internal Rate of Return *IRR* Formula | Calculation | Example, Think&Done. (Last accessed on) [14/10/2011]. Available from 〈http://thinkanddone.com/finance/irr.html〉.